THE WEATHER AND CIRCULATION OF MAY 1963

A Month with Retrogression over North America

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1. RECENT TRENDS

Retrogression of long waves in the vicinity of North America was one of the most important aspects of the mean 700-mb. circulation in May 1963. Thus there was an abrupt change in the temperature regime that had prevailed in the first two months of spring. Temperature patterns of March and April were rather stable with cool air in the Far West and warmer than normal conditions from the Rockies eastward. But in May cool air was transported into the East and North and warmth spread into the Great Basin.

Since May is a transition month between the cold months and summer, one might expect large temperature changes and little persistence in the circulation. It has been found that month-to-month persistence of temperature [1] has two minima, one from October to November and the other from April to May. For the latter minimum, for the period 1942-1957, 62 out of 100 selected cities in the United States changed by no more than one class (out of four), but for May 1963 the comparable figure was only 56. Thus the circulation changes affecting the Nation this May produced larger temperature changes than one would expect on the basis of the study referred to above.

Intra-monthly changes in circulation and accompanying weather were frequent and substantial, but there were few new monthly records, storms of widespread severity, or disastrous rains. The variability of the weather was dependent on retrogression in the circulation, much of which occurred in the last two weeks.

2. MONTHLY CIRCULATION

ATLANTIC—REVERSAL FROM APRIL

One principal component of the 700-mb. circulation for May 1963, shown in figure 1, was strong zonal flow in the Atlantic. Blocking had been a dominant feature here in some degree since December 1962. The abrupt disappearance in May of prior blocking was followed by height rises of 600 ft. (fig. 2) in middle latitudes and decreases of nearly 500 ft. near 70°N. This reversal resulted in a westerly flow that was some 10 m.p.s. faster than normal from Newfoundland to the United Kingdom. This is suggested also by the gradient of height departure from normal that exceeded 800 ft. between the Azores ridge and the Icelandic Low.

EURASIA—BLOCKING

Blocking in this area was somewhat better defined than in April (see fig. 1 of [2]) with a Low near the Black Sea and a relatively strong High about 15° lat. to the north. Strong difluence downstream from the fast flow in the Atlantic probably aided the northward growth of the ridge well into the Arctic Ocean. This strengthening over April is shown in figure 2 where it can be seen that height departures from normal in northern Siberia increased by 300 ft. or more.

Downstream from the blocking ridge a deep Low was located over northeastern Asia. Deepening extended into the western Pacific where the height anomaly changed −320 ft. over Kamchatka from April to May.

PACIFIC—AMPLIFICATION

Amplification in the Pacific was probably a contributing factor in the apparent westward motion of the major features downstream. This amplification is seen in the height departures from normal, the dotted lines in figure 1. Note that positive anomalies extend from a center near 45° N., 170° W. northward across Alaska. Figure 3 shows that the average axis of maximum wind was north of normal from 165° W. to the Asian coast, an indication of decreased westerlies in middle latitudes. An additional manifestation of reduced zonal flow was the jet that branched northward through the Bering Sea and north of Alaska.

NORTH AMERICA—RETROGRESSION

Significant changes in the circulation over and in the vicinity of North America occurred this month. While these changes at 700 mb. (fig. 2) were certainly related to other changes, it appears that retrogression of the two troughs was directly associated with the amplification in the Pacific. As the trough off the west coast deepened farther to the west, the trough in the western Atlantic also retrograded since westerlies over the United States were not sufficiently strong to support a longer wave spacing.

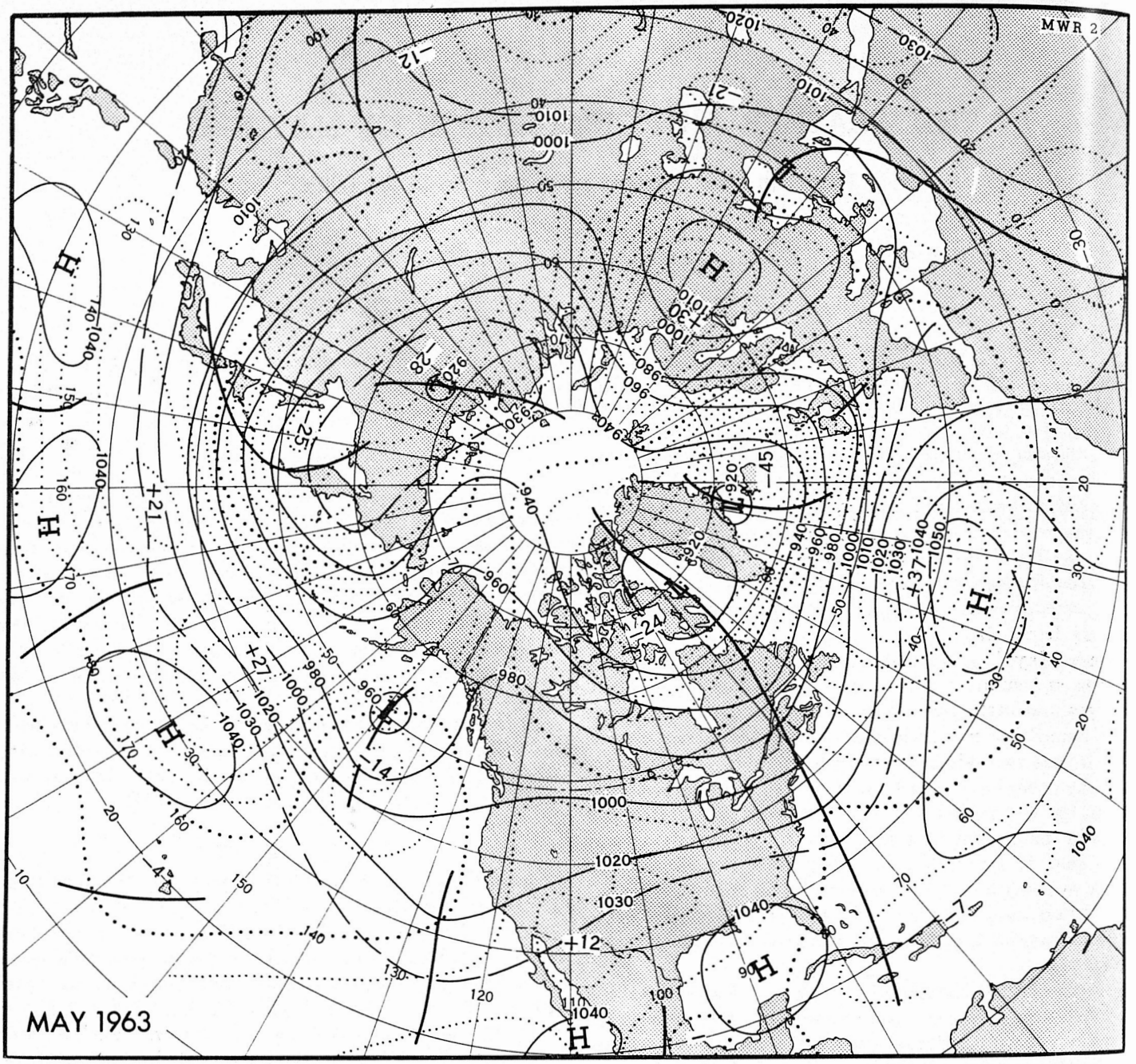

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for May 1963. Retrogression over North America was related to strong amplification in the central Pacific.

In figure 4 amplification in the Pacific is presented as seen on a shorter time scale. It appears that the central Pacific ridge amalgamated with the Alaskan ridge to form a very strong, but temporary, blocking complex in Alaska and the Gulf of Alaska. Figure 4 also shows the period of maximum retrogression during the month, indicated by the −400 ft. anomaly center over the Great Lakes. Note the relation of this center to the monthly mean center (fig. 1) which was off the east coast.

3. MONTHLY WEATHER

TEMPERATURE

Average temperature departures from normal, shown in figure 5, were small in the cooler portions of the Nation that included parts of California and Oregon and the segment that lies northeast of a line from Montana to Georgia. In much of this area temperatures were only 2° F. or less lower than normal with parts of the Ohio Valley and Middle Atlantic States a few degrees colder.

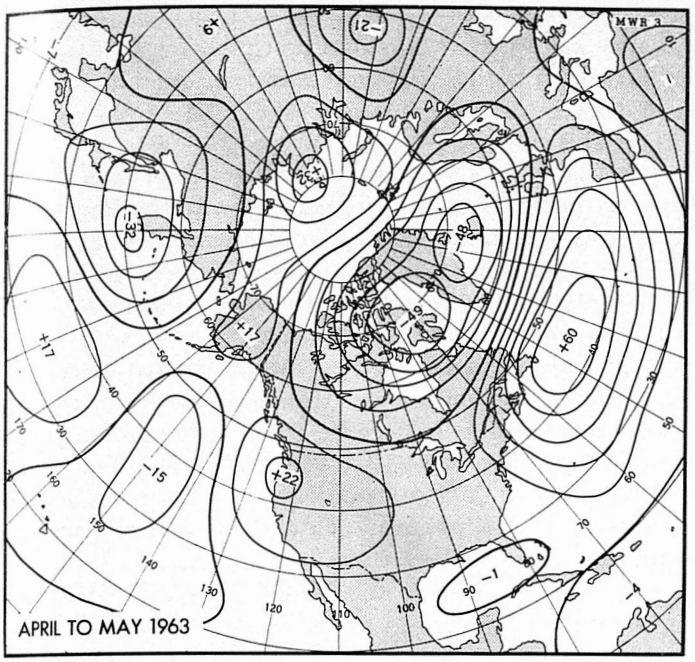

FIGURE 2.—Mean 700-mb. height anomaly change from April to May 1963. Disappearance of Atlantic blocking is indicated by large rises in middle latitudes and decreases in higher latitudes.

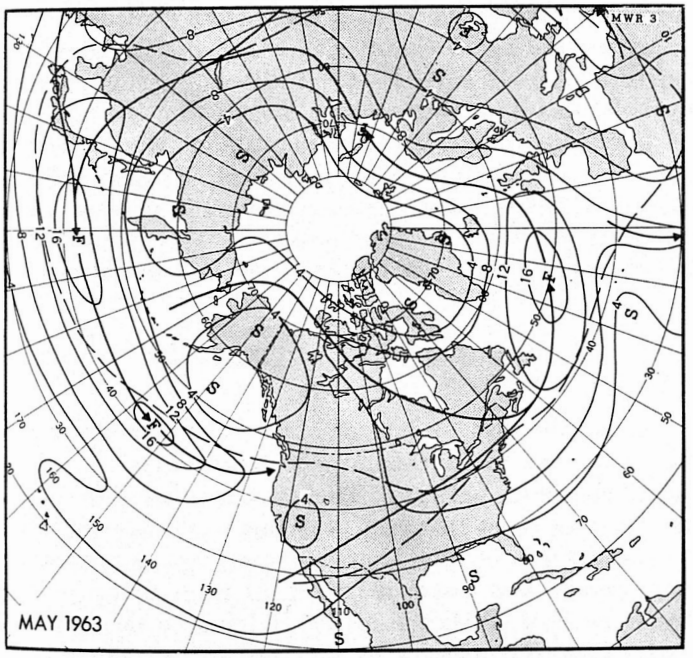

FIGURE 3.—Mean 700-mb. isotachs for May 1963. Heavy solid arrows show primary axes of mean maximum winds, and dashed lines the normal May position.

Most of the warm area was 2° F. or more higher than normal, generally from the Central Plains to the central Rockies. In the latter area some averages exceeded 4° F., but none was sufficiently large to create a new monthly record.

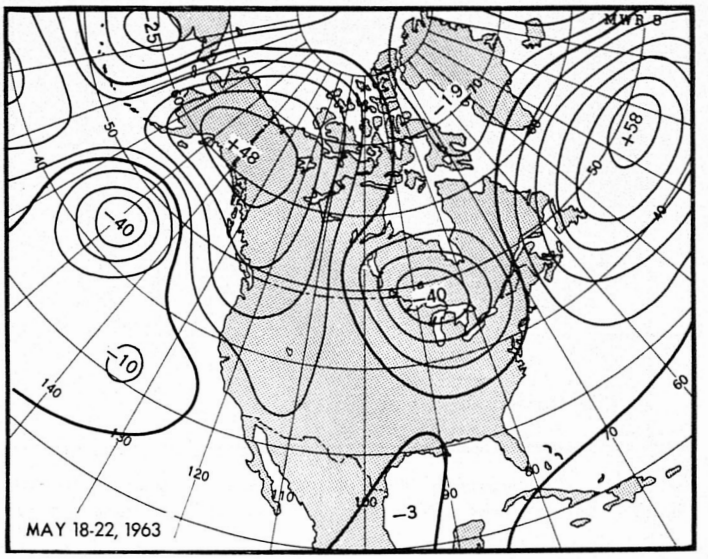

FIGURE 4.—5-day mean 700-mb. height departures from normal (tens of feet) for May 18–22, 1963. In this period retrogression and amplification were at a maximum.

This average mildness is somewhat non-representative of actual conditions, but it does reflect the non-persistence discussed earlier. Also the absence of extreme averages indicates, in this instance, exceptional variability from week to week, which will be discussed in section four.

Height departures from normal and monthly temperature anomalies are usually positively correlated. In May, however, the correlation was negative in cooler areas of the country where height departures were slightly positive. Contour curvature and the direction of anomalous flow were obviously of great importance. Note that in cool areas of the East the anomalous component was northwesterly and cyclonic and along the Pacific coast it was cyclonic and onshore, optimum conditions for cooler than normal weather in both sections.

According to early reports Barrow, Alaska (8° F. above normal), was warmer, relative to normal, than any other station in the Nation. Most stations in Alaska had positive temperature anomalies, but only at Barter Island was there a new record high average for the month (27° F.). No other monthly temperature records have been reported. This lack of extremes is due principally to the absence of

TABLE 1.—*Record minimum temperatures for May established in 1963*

City	Temperature (° F.)	Date
Milwaukee, Wis.	24	1
Youngstown, Ohio	25	24
Cleveland, Ohio	26	2
Charleston, W. Va.	28	2
Louisville, Ky.	31	1
Nashville, Tenn.	34	1, 2
Wilmington, N.C.	35	2
Augusta, Ga.	35	2
Savannah, Ga.	39	2

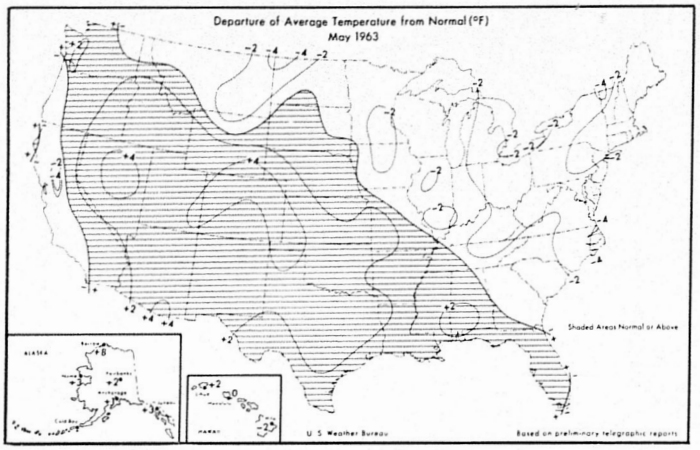

FIGURE 5.—Departure of average surface temperature from normal (° F.) for May 1963. Note absence of extremes. (From [3]).

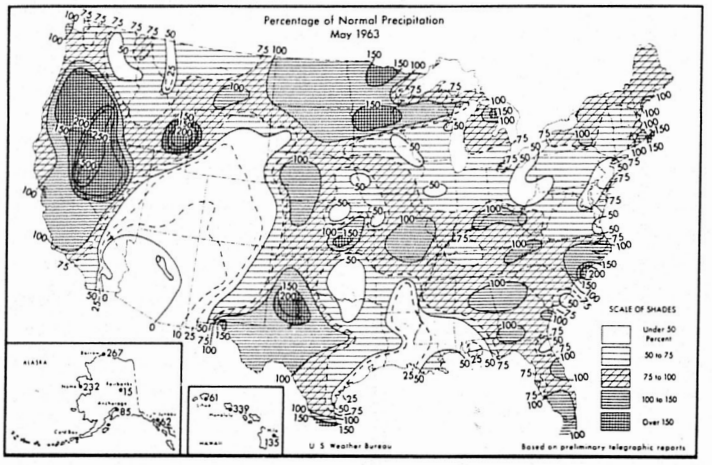

FIGURE 6.—Percentage of normal precipitation for May 1963. Heavy precipitation in the West was associated with the trough off the west coast. (From [3]).

a strong, sustained circulation regime. However, there were several newly established minimum temperature records for May as shown in table 1, and one new maximum record of 91° F. at Portland, Oreg. There were also numerous daily temperature records, most of which were new minima in States east of the Rockies.

PRECIPITATION

In the Far West the upper air flow (fig. 1) was particularly well-oriented for heavy precipitation. In this area precipitation (fig. 6) was one to three times normal and was associated with the trough offshore and the southerly anomalous component of the 700-mb. height. Among many cities that received heavy precipitation only Reno, Nev., with 2.89 in., established a new May record.

There was extreme dryness in the Rocky Mountain States well in advance of the coastal trough. From southern Arizona to central Wyoming, where some crop damage was reported, the total precipitation was less than 50 percent of normal. Precipitation was inhibited in this arid area by anticyclonic flow aloft and by the positive height anomaly.

Portions of the Gulf Coast States were drier than normal with record dryness (4.17 in. deficit) at Baton Rouge, La. This area was influenced by anticyclonic flow aloft and above normal heights. It is paradoxical that on 13 days of the month there were fronts from the vicinity of northern Louisiana to central Alabama, an area in which precipitation (2 to 3 in.) was about 25 percent of normal. In contrast, and only a short distance away, in western Texas there was as much as 6 in. of precipitation (twice normal) and there were 12 days with fronts. The principal difference in the two situations was a northerly anomalous flow in the first instance and an easterly, upslope anomalous flow in the second.

Over a large area of the Middle Atlantic States precipitation was 75 percent or less of normal in west-northwesterly flow to the rear of the coastal trough. At Washington, D.C., the combined total precipitation during April and May was 2.05 in., a new record for dryness for this period. In the Mississippi and Ohio Valleys the small areas of near normal precipitation were associated with several storms that started in the Plains and traveled generally toward New England or eastern Canada.

An interesting sidelight concerning precipitation occurred this month in the East. A rather deep storm passed over the Lakes and across New England on the first day of May. As this storm moved off the Atlantic coast, very cold continental polar air flooded the East, accompanied by snow flurries from southern Quebec to West Virginia. It was the first snow in May records for Charleston, W. Va., Wilmington, Del., and Pittsburgh and Allentown, Pa.

4. VARIABILITY DURING MAY

CIRCULATION

During the first 15 days of May the circulation at 700 mb. (fig. 7A) in the vicinity of North America had a relatively simple pattern. There was a rather deep trough off the west coast that had been inland the previous two weeks. Much of the United States was subjected to anticyclonic flow associated with the ridge that extended from the Gulf of Mexico to the Dakotas to the Beaufort Sea. However, this ridge was rather flat with above normal heights only from the Ohio and central Mississippi Valleys southwestward into Mexico. Affiliated with this weak ridge was the weak trough that extended from eastern Canada to the Gulf of St. Lawrence to the central Bahamas.

Figure 7B shows the 700-mb. circulation for the last half of May. In this period retrogression was the principal feature. The trough formerly along the west coast fractured; the southern portion remained along the California coast and southward and the upper portion reap-

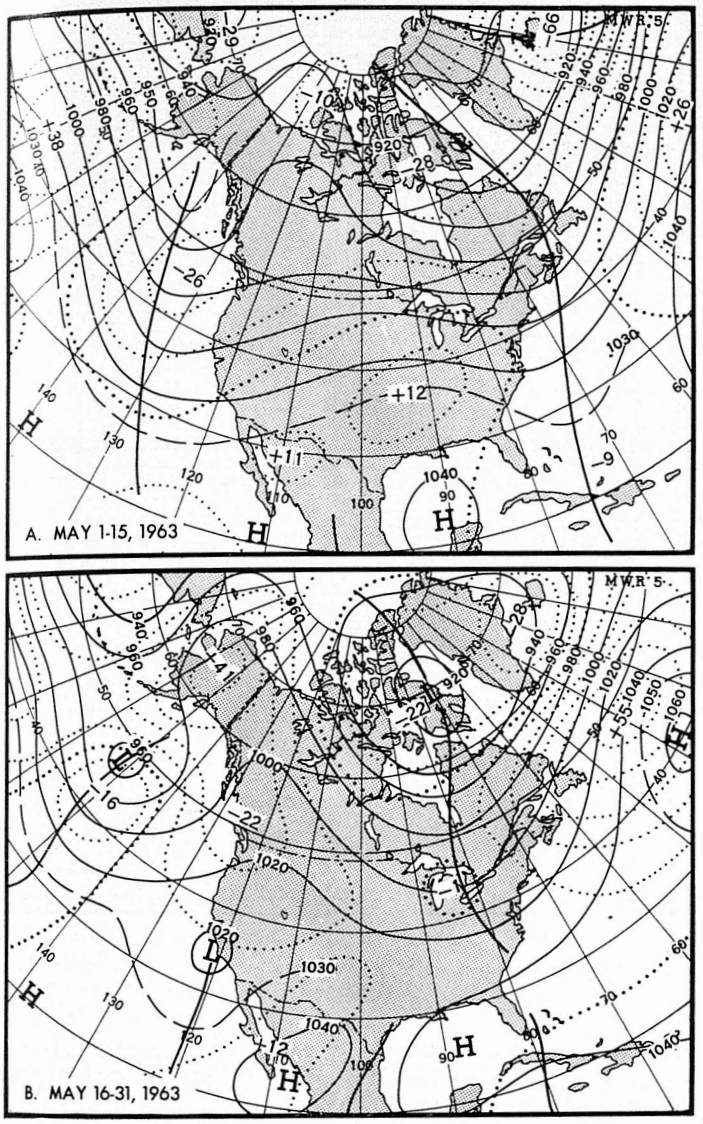

FIGURE 7.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for (A) May 1–15, 1963, and (B) May 16–31, 1963. Retrogression during last two weeks was accompanied by blocking in the eastern Pacific.

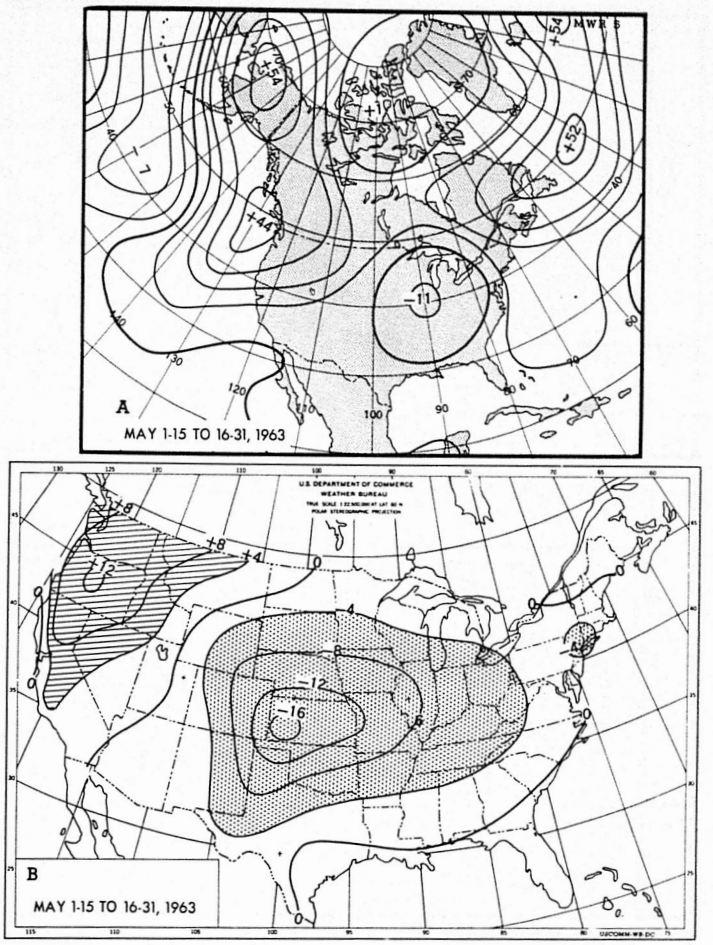

FIGURE 8.—(A) 700-mb. mean height anomaly change and (B) mean temperature anomaly change both from May 1–15 to May 16–31, 1963. In the United States temperature anomalies decreased over a much wider area than did the height anomalies.

peared some 10° of longitude farther west. Meanwhile the continental ridge also moved farther to the west and strengthened appreciably in the north. Downstream the next trough was near 80° W. in the United States, a westward displacement of 10°–20° of longitude in the last two weeks of May.

This retrogression of principal features during May may be inferred from figure 8A, the height change from the first two weeks of May to the last two weeks. Height falls of 270 ft. in the central Pacific and rises along the west coast indicate retrogression of the long-wave trough; the fall–rise pattern from Illinois to Newfoundland represents the apparent westward motion of the eastern trough; and the increases of up to 540 ft. over Alaska and into western Canada imply a strengthening of the ridge. It is of interest that despite this amplification, the trough immediately downstream did not deepen, possibly a result, to some degree, of the confluence between the flow from the Low along the California coast and the northwesterly flow in the lee of the northern Rockies.

TEMPERATURE

Consequences of the evolution described above appear in figure 8B, temperature anomaly changes from the first half of May to the last half. As the North American ridge retrograded, Highs of continental polar origin were steered southward on tracks much farther west (see chart VIII of [4]) in the latter part of May than earlier in the month. These paths in western Canada were considerably farther west than usual (see chart 65 of [5]), and cold air thus penetrated the United States as far west as the central and southern Rockies.

As heights increased in the western United States (fig. 8A) temperature anomalies increased by 8°–12° F. in the Pacific Northwest (fig. 8B). Contrariwise, temperature

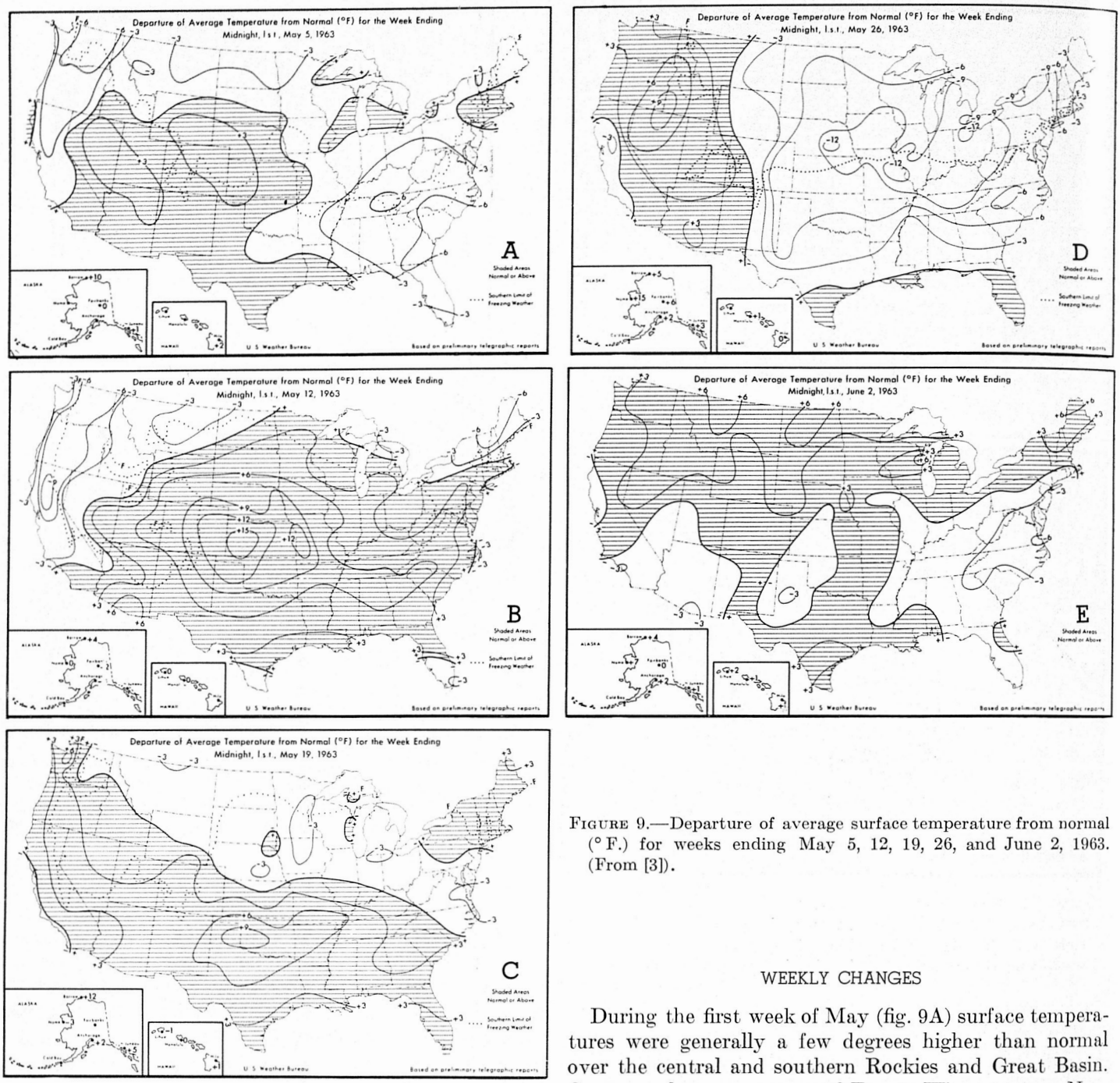

FIGURE 9.—Departure of average surface temperature from normal (° F.) for weeks ending May 5, 12, 19, 26, and June 2, 1963. (From [3]).

anomalies decreased over most of the Nation east of the Rockies. Over most of the area where temperatures decreased, there were 700-mb. height falls, except in western Kansas where there was maximum cooling relative to normal (12°–16° F.), but height changes were negligible. However, the direction of the anomalous height flow changed from southwesterly (fig. 7A) to northerly (fig. 7B), a direction that encourages cooling even when heights are not lower than normal.

WEEKLY CHANGES

During the first week of May (fig. 9A) surface temperatures were generally a few degrees higher than normal over the central and southern Rockies and Great Basin. Greatest departure was 6° F. at Winnemucca, Nev. Cooler air prevailed in other sections except for small areas of near normal temperatures in the Lakes region and New England. Temperatures as much as 7° F. below normal were reported in the Pacific Northwest and also in South Carolina and Georgia.

Widespread warming occurred in the second week (fig. 9B) over the eastern three-fourths of the Nation. Temperatures were 9°–16° F. above normal (with daily maxima in the middle and high 90's) in the Kansas-Oklahoma-Texas-Colorado area.

In the third week (fig. 9C) there was substantial cooling from the Central Plains States to the Middle Atlantic States. In this period the retrogression of mean features

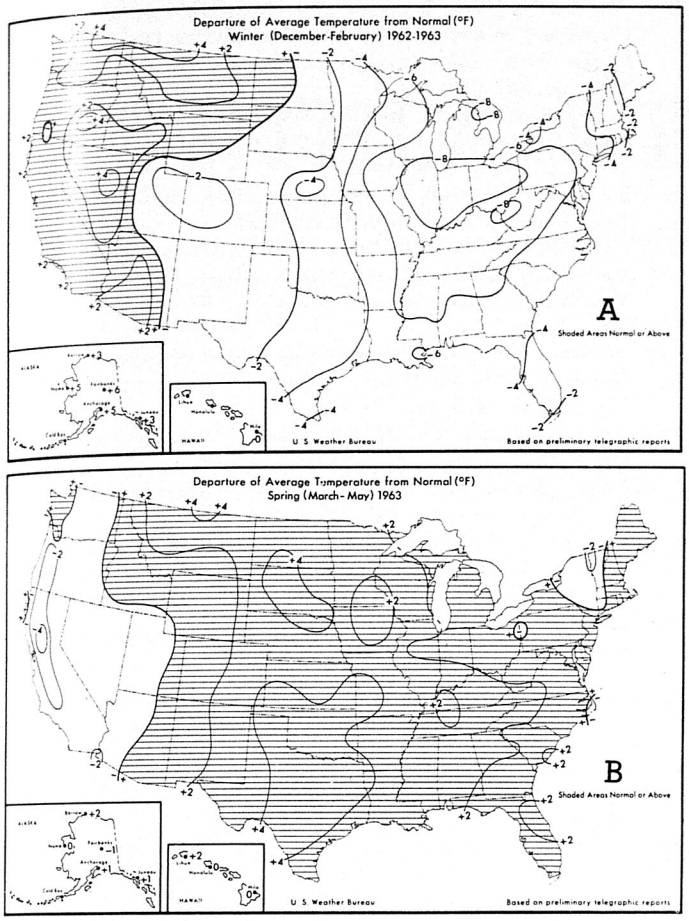

FIGURE 10.—Departure of average surface temperature from normal (°F.) for (A) winter 1962–1963 and (B) spring 1963. Note remarkable reversal of pattern. (From [3]).

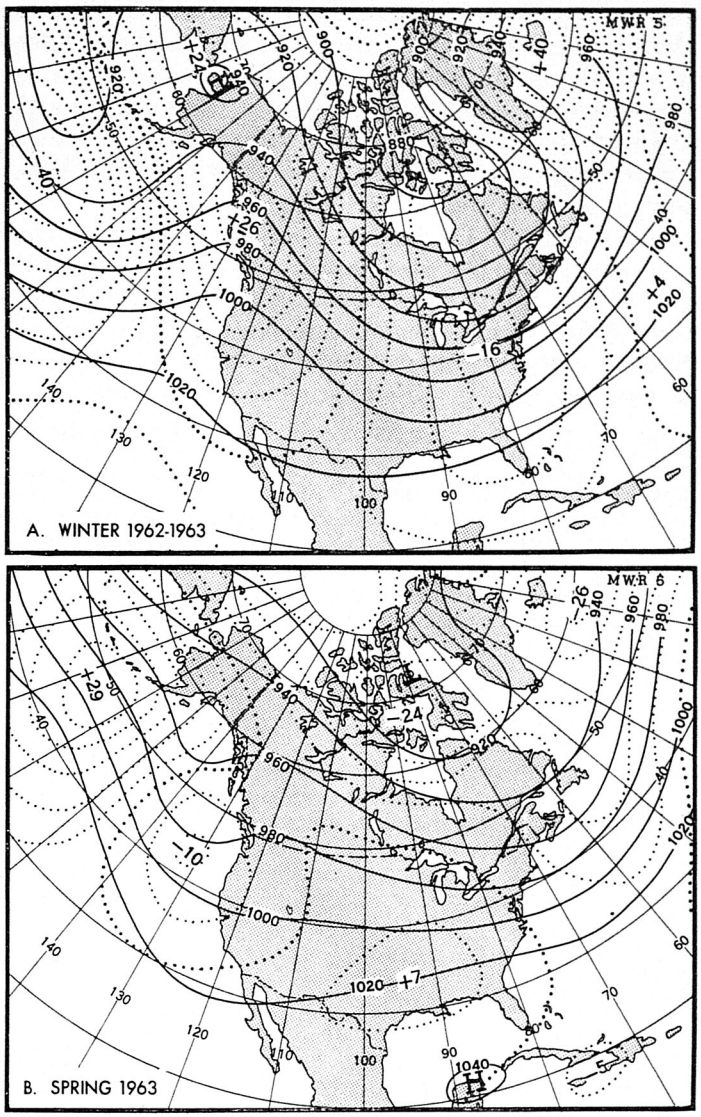

FIGURE 11.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for (A) winter 1962–1963 and (B) spring 1963. Meridional flow in winter and zonal flow in spring were the outstanding features.

reached maximum westward positions (fig. 4) and the ridge in western North America was very strong. Temperature departures were not large owing to the variability of the circulation this week.

An Arctic High the fourth week dropped average temperatures (fig. 9D) lower than normal over the country from the Rockies to the east coast. In this coldest week of the month, temperatures were 9°–12° F. below normal from the Central Plains to the Ohio Valley. West of the Rockies warm air prevailed except in parts of California.

Rapid warming in the week ending June 2 (fig. 9E) resulted when a more westerly flow replaced the amplified flow of the previous two weeks. Some coolness remained, especially in the southeastern quarter where temperatures were 3°–6° F. lower than normal. Warming by similar amounts was common in northern portions.

5. SEASONAL REVERSAL

A marked reversal of temperature anomalies this spring followed one of the coldest winters of record in the eastern two-thirds of the Nation, the severity of which has been reported previously in this series [6, 7, 8]. Average departures for winter of 1962–1963 ranged to 4° F. higher than normal in the Northern Plains States and west of the Divide. The balance of the Nation was very cold with the largest departures (6°–9° F.) in the mid-section from the central Mississippi Valley to the Middle Atlantic States.

Compare figure 10B, the departure of average temperature from normal for spring 1963, with figure 10A and note the remarkable changes. The Great Basin and Far West became colder than normal and the balance of the United States was generally a few degrees warmer than normal.

These contrasting seasonal temperature regimes were

associated with the circulation patterns shown in figure 11. During winter the very strong ridge and northerly direction of the height anomaly (fig. 11A) favored repeated, strong outbreaks of Arctic air masses. In spring (fig. 11B) heights were below normal in western Canada and there was a trough along the west coast. These conditions encourage warmth east of the Rockies.

Compared with the winter season, spring was rather unspectacular with few new records. Reno, Nev., reported the wettest spring since records began with more than three times normal rainfall associated with the coastal trough. Other records include the warmest spring at Dallas, Tex., and the driest spring at Lake Charles, La.

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CORRECTION

Vol. 91, No. 6, June 1963, p. 287: Figure 22 should be credited as follows, "(After Ward [34])."

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